DESIGN AND ANALYSIS OF A MRI MINIATURE FOR CHILDREN

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

Magnetic Resonance Imaging (MRI) is a machine that had been used for imaging the internal section of our body by using the principal the magnetic field. In the process of the imaging, the patient must follow the instruction so they did not move along the process because it will affect the result. Children also not excluded from gone through the process. This MRI also produces very noisy sound produces loud thumping and humming noises during imaging. So, for the children, sometimes they get too frightened to get along the examination process. By using the miniature, it help to reduce and to distinguished that feeling and to avoid others parameter that will damage the examination result. The design of a MRI miniature was design in the solidworks software and being analysis by Cosmos. The result was being taken from three aspects which are stress analysis, displacement analysis, and deformation analysis. The new design of miniature could uphold the load of average children's weight within 45kg or 441.45 N.

ABSTRAK

Pengimbas Magnetik Resonan adalah satu mesin yang digunakan untuk pengimbasan bahagian dalaman badan manusia dengan menggunakan prinsip medan magnet. Dalam proses pengimbasan, pesakit mestilah mengikut arahan yang telah diberikan supaya pesakit tidak bergerak sepanjang proses pengimbasan dijalankan kerana setiap pergerakan akan member kesan kepada keputusan pengimbasan nanti. Kanak-kanak juga tidak terlepas dari melalui proses pengimbasan. Mesin MRI ini juga mengeluarkan bunyi yang kuat dan bingit ketika proses pengimbasan sedang berjalan. Oleh itu, untuk kanak-kanak, mereka akan menjadi ketakutan untuk meneruskan proses pemeriksaan pengimbasan. Dengan menggunakan model kecil mesin pengimabasan magnetic resonan dapat membantu mengurangkan dan menghapuskan perasaan takut kanak-kanak dan juga untuk mengelakkan perkara-perkara tidak diingini yang akan merosakkan keputusan pengimbasan. Reka bentuk model ini telah dilakukan dengan menggunkan perisian Solidworks dan dianalisis menggunakan perisian Cosmos. Keputusan dari analisa di rangkumkan mengikut tiga aspek iaitu, analisis ketegangan, analisis pemindahan, dan analisis perubahan struktur. Reka bentuk model yang baru ini dapat menampung beban yang diletakkan iaitu berat kanank-kanak seberat 45 kg ataupun 441.45 N.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

mm	Milimiter
cm	Centimeter
σ	True stress, local stress
$\Delta\sigma$	Stress range
σ_a	Local stress amplitude
σ_m	Local mean stress
σ_{max}	Local maximum stress
σ_f	True tracture strength
N	Newton
ε	Strain

LIST OF ABBREVIATIONS

MRI	Magnetic Resonance Imaging
CAD	Computer Aided Design
CT	Computed tomography
QFD	Quality Functional Diagram
HOQ	House of quality
ABS	Acrylonitrile butadiene styrene
RF	Radio frequency

CHAPTER 1

INTRODUCTION AND GENERAL INFORMATION

1.1 INTRODUCTION

Magnetic resonance imaging (MRI), is primarily a medical imaging technique most commonly used in radiology to visualize detailed internal structure and limited function of the body and making it especially useful in neurological (brain), musculoskeletal, cardiovascular, and oncological (cancer) imaging. MRI uses no ionizing radiation, but uses a powerful magnetic field to align the nuclear magnetization of hydrogen atoms in water in the body. Radio frequency (RF) fields are used to systematically alter the alignment of this magnetization, causing the hydrogen nuclei to produce a rotating magnetic field detectable by the scanner. This signal can be manipulated by additional magnetic fields to build up enough information to construct an image of the body.

The basic design of MRI in most is a giant cube. The cube in a typical system might be 7 feet tall by 7 feet wide by 10 feet long (2 m by 2 m by 3 m), although new model are rapidly shrinking. There is a horizontal tube running through the magnet from front to back. This tube is known as the bore of the magnet.

The patient, lying on his or her back, slides into the bore on a special table. Whether or not the patient goes in head first or feet first, as well as how far in the magnet they will go, is determined by the type of exam to be performed. MRI scanners vary in size and shape, and newer models have some degree of openness around the sides, but the basic design is the same. Once the body part to be scanned is in the exact center or isocenter of the magnetic field, the scan can begin.

In conjunction with radio wave pulses of energy, the MRI scanner can pick out a very small point inside the patient's body. The MRI system goes through the patient's body point by point, building up a 2-D or 3-D map of tissue types. It then integrates all of this information together to create 2-D images or 3-D models**.**

1.2 BACKGROUND OF PROBLEM

MRI is a relatively new type of diagnostic imaging procedure using latest technology that can examine the internal part of human body. Traditionally people relied on X-rays, or radiographs to look inside the body. X-rays only produce flat black and white images, and the examination only shows tissue and bones looking for fractures or related defects. MRI is another way of seeing the internal part of the body without radiation by using a large magnet, radio waves and a computer. MRI can help us visualize body tissues in a different way. MRI images are highly detailed and allow us to diagnose internal part of body. It is almost like taking cuts or slices of the body but in a virtual yet highly accurate way on the computer.

Before using MRI device, patients must follow the preparation to do the examination. Patients should not have eaten or drank anything for at least 3 hours prior to the examination. All jewelry, hair pins, contact lenses, make up, nail polish, pins, zippers and buttons should be removed to avoid the effect of magnetic field. If the person undergoing a MRI examination is claustrophobic which is afraid to a narrow space, a sedative medication may be given to help them relax during the procedure. This procedure also must be following to the children which are age between 2 to 8 years old that undergoing this examination. However, younger children are very hyperactive and need to be sedated so they do not move during the examination because the process takes very long period within 35 to 60 minutes. Each process costs RM 300.00 per examination. If they move the examination have to be cancelled and need to pay another cost. Avoiding movement is to cut the cost per examination.

The specific type of sedation depends on the age and individual circumstance. Most children MRI facilities allow the parent to remain with their child during the examination. MRI miniature help children get familiar to examination process.

1.3 PROJECT OBJECTIVES

The objectives of this research are focus on:-

1) To design a Magnetic Resonance Imaging miniature for children.
2) To analysis the design of the Magnetic Resonance Imaging miniature for children by using COSMOSXPRESS.

1.4 SCOPE OF PROJECTS

This project focused on design the MRI miniature for children that compatible with the age 3 to 8 years old by using the Computer Aided Design (CAD) software Solid work in term of all the part of the miniature. Then the analysis of the design of the miniature by using COSMOSXPRESS software to determine the value of the maximum load that can be apply to the miniature of the MRI. The value of the load currently took from the weight of children in the range of 3 to 8 years old. The maximum value of the children's weight which is 45kg can be applied on the miniature.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A miniature is a small-scale reproduction, or a small variation. It may refer to many types of miniature meanings. It can be in term of illuminated manuscript, and a scale model. Nowadays, miniature is synonym to model that being built to do many things, such as, modeling of house, toys, aircraft and many things. Some people do the miniature as their hobby during free time, even they have their own society in making the miniature. MRI Miniature was targeted to children in the range of 3 to 8 years old in order to make the children not to move while in the examination process by making the children get used to the MRI machine by playing the miniature.

2.2 MINIATURE OF MAGNETIC RESONANCE IMAGING

MRI in basic has a gigantic in size but has a small bore to get body into it and also produces very noisy sound during imaging process. So, for the children, sometimes they get too frightened to get along the examination process. By using the miniature, it will help to reduce and to distinguish that feeling and to avoid others parameter that will damage the examination result.

In the real modern world, now biggest Electrical Company like PHILIPS had invent new product of the MRI miniature to overcome this problem. It is a scaled version of the Computed Aided Tomography (CAT) scan that the child will be confronted with during the examination and includes a television screen and toys and

through play, it teaches the child about the procedure they are about to face. It is called as Kitten Scanner.

An animation on the Television screen invites the child to choose an animal character a crocodile, elephant, robot or chicken and place it on the bed of the Kitten Scanner. The child can then slide the bed and character into the bore of the scanner, mimicking what happens in reality. When the animal character is in the bore of the scanner, its embedded Radio Frequency tag activates an animation on the Television screen, telling the story of that particular character. Who is the character, what did they do, why they need to go to the hospital for a scan. Through this story-telling, the animation shows children about how a real CAT scanner works, and how doctors examine internal of human body.

2.3 USER NEEDS

There are an interview conducted by Norhaida bt Abdul Razak and two others friends in the Hospital Universiti Kebangsaan Malaysia on 4th and 6th of August 2008 to the MRI patients and users. There are four questions that have been asked, typical use, likes tools, what is the dislike, suggested improvement. This question is just to survey how the patients feel about using the MRI.

2.4 TYPICAL USE

By the data given from the interview, it is all about the main usage or application of the MRI. The patient has to lay down on the MRI in order to get the patient into the MRI bore. The patient also has to wait for a long period until the process done. One single process, take 35 to 60 minutes depends on type of the examination. The condition of MRI must be pleasant so the patient does not feel uncomfortable.

2.5 LIKE-TOOLS

MRI does not generate any radiation. Unlike conventional x-ray examinations and computed tomography (CT) scans, MRI does not depend on ionizing radiation.

Instead, while in the magnet, radio waves redirect the axes of spinning protons, which are the nuclei of hydrogen atoms, in a strong magnetic field.

The magnetic field is produced by passing an electric current through wire coils in most MRI units. Other coils, located in the machine and in some cases, placed around the part of the body being imaged, send and receive radio waves, producing signals that are detected by the coils.

A computer then processes the signals and generates a series of images each of which shows a thin slice of the body. The images can then be studied from different angles by the interpreting physician.

Overall, the differentiation of abnormal (diseased) tissue from normal tissues is often better with MRI than with other imaging modalities such as x-ray, CT and ultrasound.

2.6 THE DISLIKE

Before doing the examination, there are some regulation that must be followed by the patients, which is guidelines about eating and drinking before MRI exam vary with the specific exam and also with the facility. For some types of exams, patients will be asked to fast for 8-12 hours. Unless patients are told otherwise and may follow the regular daily routine and take medications as usual.

Some MRI examinations may require the patient to swallow contrast material or receive an injection of contrast into the bloodstream. The radiologist or technologist may ask if the patient have allergies of any kind, such as allergy to iodine or x-ray contrast material, drugs, food, the environment, or asthma. However, the contrast material used for an MRI exam, called gadolinium, does not contain iodine and is less likely to cause side effects or an allergic reaction.

Women should always inform their physician or technologist if there is any possibility that they are pregnant. MRI has been used for scanning patients since the

1980's with no reports of any ill effects on pregnant women or their babies. However, because the baby will be in a strong magnetic field, pregnant women should not have this exam unless the potential benefit from the MRI is assumed to outweigh the potential risks

Besides, for patient that has claustrophobia (fear of enclosed spaces) or anxiety, you may want to ask your physician for a prescription for a mild sedative. So, MRI should have a very large confined area. This always happened to the children; MRI also produced noise from the magnetic process, which must have to turn the noise to something nice to hear, such as natural symphony song or relax sensation.

2.7 QUALITY FUNCTIONAL DEPLOYMENT

In order to design the miniature, there are some preferences that take part. Quality Function Deployment (QFD) was developed to bring this personal interface to modern manufacturing and business. In today's industrial society, where the growing distance between producers and users is a concern, QFD links the needs of the customer (end user) with design, development, engineering, manufacturing, and service functions. Quality Function Deployment can be describing as below:

1. Understanding Customer Requirements
2. Quality Systems Thinking with Psychology and Knowledge or Epistemology
3. Maximizing Positive Quality That Adds Value
4. Comprehensive Quality System for Customer Satisfaction
5. Strategy to Stay Ahead of The Game

As a quality system that implements elements of Systems Thinking with elements of Psychology and Epistemology (knowledge), QFD provides a system of comprehensive development process for:

- Understanding 'true' customer needs from the customer's perspective
- What 'value' means to the customer, from the customer's perspective

- Understanding how customers or end users become interested, choose, and are satisfied
- Analyzing how do we know the needs of the customer
- Deciding what features to include
- Determining what level of performance to deliver
- Intelligently linking the needs of the customer with design, development, engineering, manufacturing, and service functions
- Intelligently linking Design for Six Sigma (DFSS) with the front end Voice of Customer analysis and the entire design system

2.8 TECHNIQUES AND TOOLS OF QFD

The techniques and tools are divided into three, which are:

1. House of Quality
2. Pugh concept selection
3. Modular Function Deployment

2.8.1 House of Quality (HOQ)

House of Quality appeared in 1972 in the design of an oil tanker by Mitsubishi Heavy Industries. The House of Quality is not QFD; it is just an example of one tool for such an example in Figure 2.1. A Flash tutorial exists showing the build process of the traditional QFD "House of Quality" (HOQ). (Although this example may violate QFD principles, the basic sequence of HOQ building is illustrative.) There are also free QFD templates available that walk users through the process of creating a House of Quality.

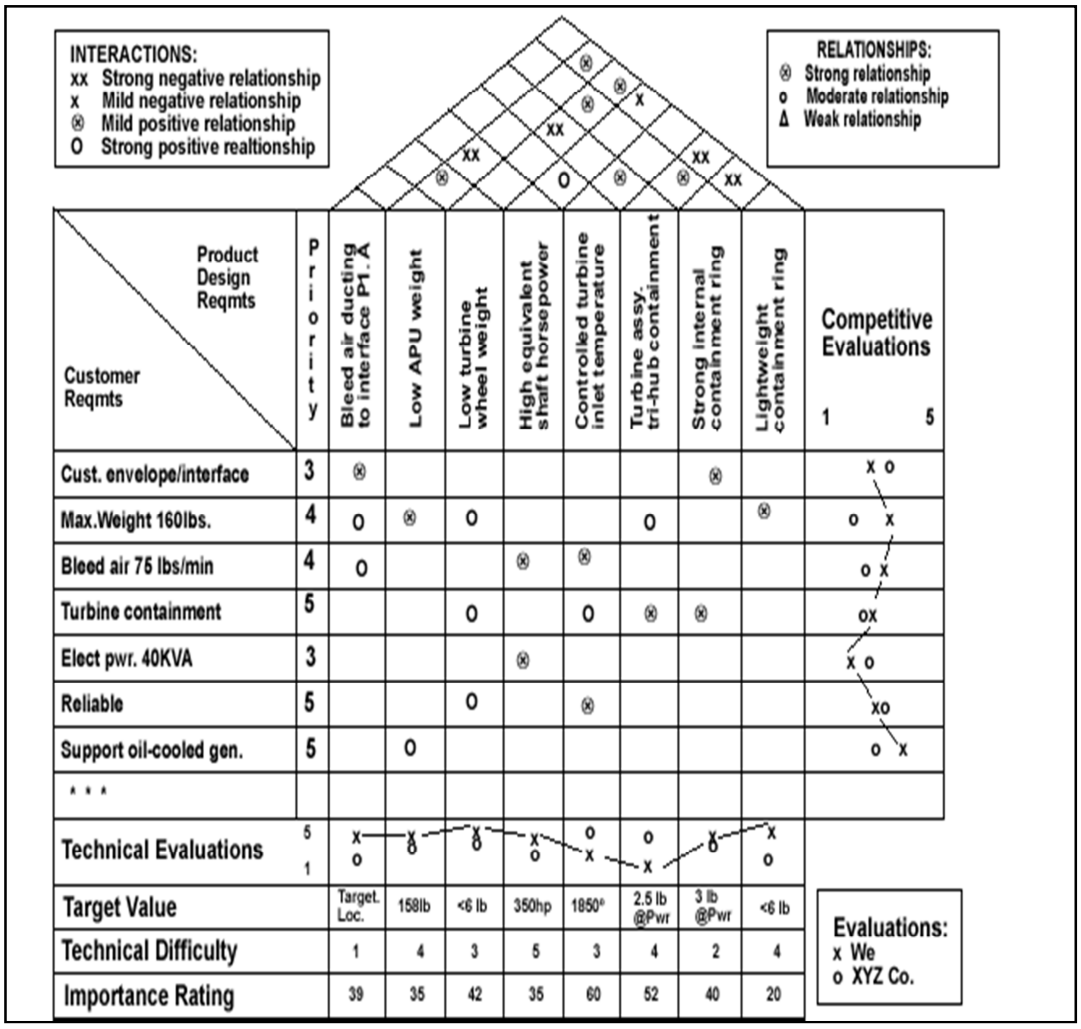

Figure 2.1: House of Quality Diagram

Source: Ulrich, 1991

2.8.2 Pugh selection concept

Pugh Concept Selection can be used in coordination with QFD to select a promising product or service configuration from among listed alternatives. Pugh concept selection are related to others activity. Pugh method diagram can be shown in the diagram as shown in Figure 2.2.

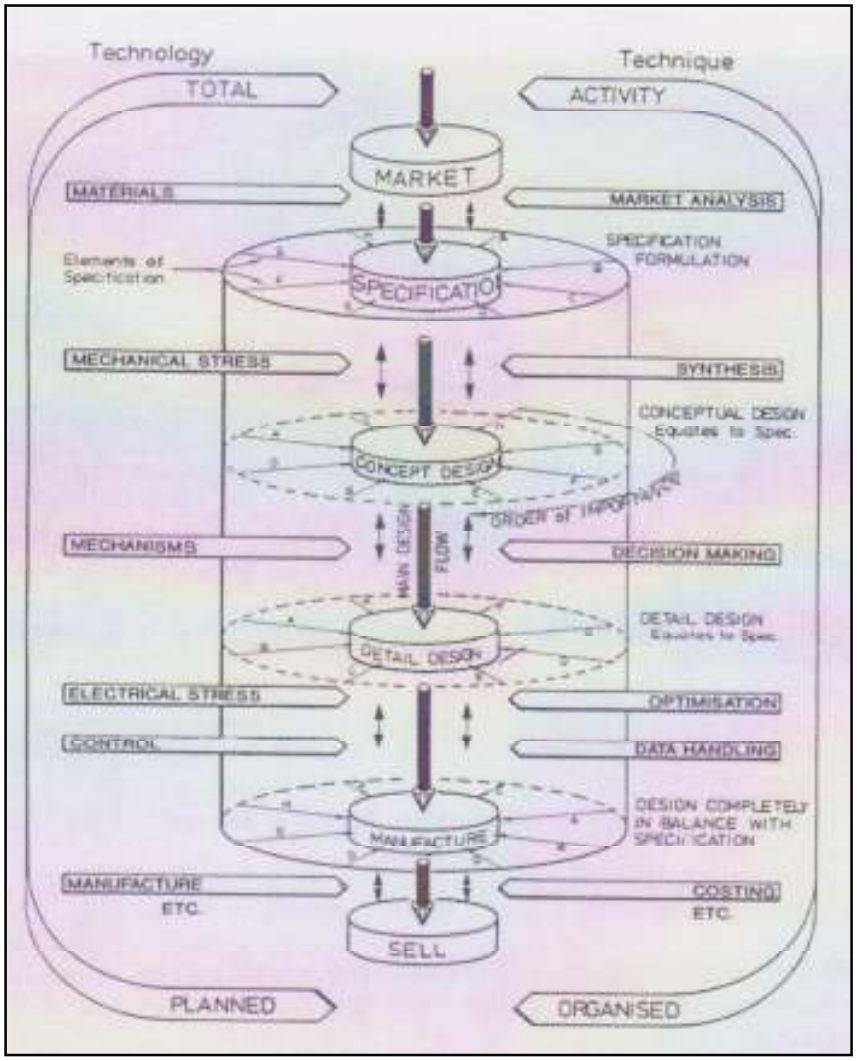

Figure 2.2: Pugh method concepts

Source: Ulrich, 1991

2.9 MODULAR FUNCTION DEPLOYMENT

Modular Function Deployment uses QFD to establish customer requirements and to identify important design requirements with a special emphasis on modularity. The techniques and tools, makes the process of designing easier and efficient. It can reduce the time taken used by the designer.